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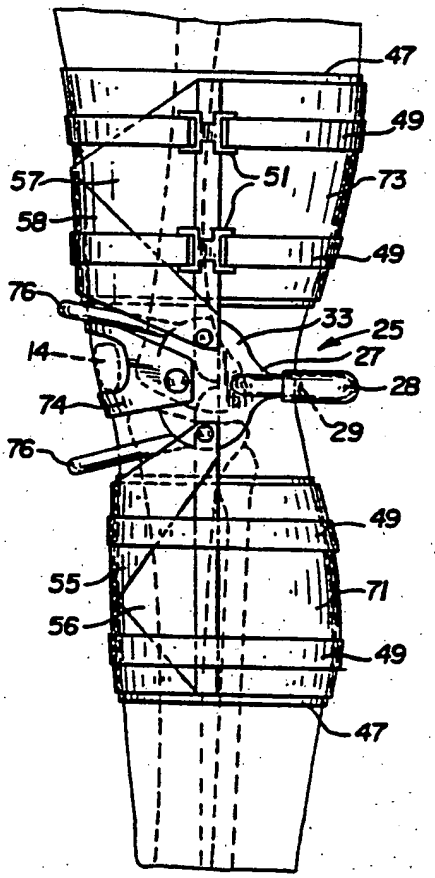
(54) Title: KNEE BRACE WITH POSTERIOR STRUT

(57) Abstract

A knee brace (23) has a rigid posterior strut (25) behind the knee joint (1) in the popliteal area (29) with terminal portions (31, 33) adjacent, but spaced from the lateral and medial sides of the knee. A prophylactic embodiment of the invention has a lateral inferior rigid support member (35) pivoted on the lateral terminal portion (31) of the strut (25) and secured to the leg (13), and a medial superior rigid support member (39) pivoted on the medial terminal portion (33) of the strut and secured to the thigh (7). Stiff anterior, generally triangular, cuff members (55, 57) each have one edge (59) secured to one of the rigid support members (35, 39) and an opposite vertex (61) detachably, pivotally secured to the opposite terminal portion (31, 33) of the strut.



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KNEE BRACE WITH POSTERIOR STRUT

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to an orthopedic support device, specifically a rear strut stabilized, derotational knee brace which may be used for prophylactic, functional and rehabilitative applications.

Background Information

Generally knee braces may be classified according to the function they perform. Prophylactic knee braces are used to reduce the likelihood of injury during activities, particularly sports, in which high loads are placed on the knee joint. Usually, an objective of prophylactic knee braces is to provide some support for the joint without unduly restricting movement, thus reducing the risk of injury to a normal knee joint. Functional knee braces are used to support and stabilize injured joints, and hence, provide the strongest reinforcement for the knee. They often prohibit certain movements. Rehabilitative knee braces are used to support previously injured joints and are used extensively during post operative and rehabilitation periods. Their designs generally lie between prophylactic and functional braces in the amount of support they provide, and the degree of restriction they impose on joint movement is usually adjustable to provide only a specific range of desired motion.

Prophylactic supports for the knee joint include wraps of adhesive or elastic tape and reinforced neoprene sleeves. These devices, however, do not provide the support generally required. Prophylactic knee braces have been designed as single hinged vertical members placed laterally on one side of the leg and held by cuffs and straps to the thigh and the leg. Since the anatomy in the knee region is naturally offset, the fixation on one side cannot support the brace effectively. These braces tend to slip, thus exerting undue forces acting against the natural kinematics on the knee joint, and also concentrate forces laterally on the knee, which in some cases, increases the risk of medial collateral ligament or anterior cruciate ligament injury. Several studies have demonstrated the ineffectiveness of such braces in preventing knee injury and in some cases, have demonstrated an increase in foot and ankle injuries as well. This may be due to the slippage of the brace which may cause interference with normal kinematic operation of the knee. This results in fatigue of the thigh and leg muscles, increasing the strain on knee ligaments and the knee joint, thus increasing the risk of injury. In addition, the medial collateral ligament can be preloaded by a lateral brace, increasing the probability of a medial collateral ligament rupture. The bunching up of the support materials in the popliteal space behind the knee, in braces which utilize "fillers" between parts, further contributes to this problem.

Functional knee braces typically have medial and lateral rigid supports for the knee joint. Many of these devices have complicated hinge structures designed to accommodate for the femoral rollback which occurs upon flexion of the knee joint. Some of these braces use rigid molded thigh and leg cuffs to support the hinged lateral and medial support members. Other braces have utilized spiral

structures and straps to connect the thigh and leg cuffs. These devices have not proven as effective as desired to protect against a knee injury and to support and stabilize an unstable knee or protect an injured knee. The major disadvantage of these rigid braces is slippage due to the conical shape of the lower extremity. With slippage, even a well designed brace can alter the kinematics of the knee and increase the risk of injury. Altering the normal motion of the knee also causes muscle fatigue, thus, increasing risk of injury. These braces with rigid molded cuffs which capture the knee, prevent the musculature surrounding the knee from effectively absorbing the forces induced around the joint. Existing functional braces have not been proven to effectively control anterior instability at high loads.

Another type of knee brace uses an adjustable rigid or semi-rigid member encircling the knee joint which clamps lateral and medial pads against the knee joint. The proper operation of such braces depends on the exact fit on a specific knee, and therefore must be custom fitted. They are also bulky and generally more expensive. These devices tend to unduly restrict motion of the knee joint. Because of their more complex nature and bulkiness, interference with normal knee operation is higher if the hinge is misaligned.

There remains a need therefore for an improved knee brace for prophylactic, functional and rehabilitative applications.

There is also a need for such an improved knee brace which provides the required support for the knee without undue restriction on the natural movement of the joint.

There is also a need for such an improved knee brace which does not increase the risk of injury.

There is a further need for such an improved knee brace which distributes the load to the fleshy parts of the thigh and leg.

There is yet another need for such an improved knee brace which reduces both shear and torsion forces applied to the knee.

There is still another need for such an improved knee brace which does not slip out of position or bind.

There is an additional need for such an improved knee brace which is light weight and easy to apply and remove.

There is also a need for a knee brace which can be readily and easily adjusted to accommodate for individual knee characteristics and provide the surgeon/physiotherapist with a means for adjusting for abnormal knees for either improved brace fit, optimizing brace function/action for individual patients, or compensating for or controlling specific motions or actions. Adjustments may also be required or desirable during the course of treatment to accommodate for reduction in swelling, changes caused by treatment, or growth as in a child. It would also be desirable to have a single, or only a few basic sizes of the brace, which could be readily adapted to the circumstances, as opposed to the custom modeling and fabrication or the stocking of numerous sizes as required by many other braces.

SUMMARY OF THE INVENTION

These and other needs are satisfied by the invention which is directed to a knee brace which includes a rigid posterior strut located in the popliteal space of the knee and to which all other parts of the brace are attached. The popliteal space behind the knee is the ideal location for fixing the reference point for a knee brace

because (a) a rigid strut in the popliteal space does not interfere with the natural motion of the knee and/or the natural action of the leg; (b) any external forces acting on the knee through the mechanical strut are least likely to cause injury to the wearer, since the popliteal space is the only part of the knee where there is adequate soft tissue to absorb harmful energy; (c) the flexion and extension action of the knee relocates the brace into its proper position due to the action of the soft tissue in the popliteal region on the strut; and (d) the posterior strut provides a fixed reference point to which other functional parts of the brace may be attached giving design flexibility for prophylactic, functional and rehabilitative applications.

Because the knee brace of this invention has a posterior strut to which vertical supports are connected by hinges, laterally applied forces at the knee are transmitted to the medial side of the brace, thus preventing injury to the medial collateral ligament. Also, medially directed forces are transmitted to the lateral side, bypassing the knee joint.

The embodiment of the knee brace of this invention for prophylactic applications has a lateral inferior rigid support member which attaches to the leg, and a medial superior rigid support member which attaches to the lower thigh. Both of the rigid support members are pivotally connected on terminal portions of the rigid posterior strut. The pivot points are selected to reproduce the natural kinematics of the knee joint, including posterior femoral rollback. In the preferred form of the brace, stiff cuff members, preferably generally triangular in shape, are secured to the rigid support members and extend around the front of the thigh and calf and are pivotally connected to the opposite terminal portion of the posterior strut. The

rigid support members are secured to the leg and thigh, respectively, by anchor means, preferably in the form of soft, resilient sleeves which may be held in place by straps secured such as by VELCRO fasteners. Any open spaces between the rigid support members, cuffs, thigh and calf are filled by the resilient sleeves, which, however, do not extend around the knee joint.

The rigid posterior strut transfers forces acting on the knee around critical areas, dissipating some of the forces so transferred into the soft tissue surrounding the popliteal space. The action of the soft tissues on the posterior strut during normal extension/flexion of the knee causes the brace to self-center. The rigid posterior strut also serves as a known fixed anchor point for the elongated hinged members and the upper and lower cuffs, and may be used to attach any reinforcing, adjusting or motion correcting straps which may be desired for a specific injury. The upper and lower stiff cuffs attached as they are over the soft, resilient sleeves distribute forces acting on the knee through a wide area of the primarily soft tissue in the medial thigh and lateral upper leg areas. They also assist the rigid posterior strut in transmitting torsional forces around the knee joint.

For functional and rehabilitative applications, the brace includes a superior lateral elongated member secured to the thigh and pivotally connected to the lateral terminal portion of the rigid posterior strut and a medial elongated member secured to the leg and pivotally connected to the medial terminal portion of the rigid posterior strut. Thus, in this embodiment of the invention, elongated members extend medially and laterally along both the thigh and the leg to provide additional stability and support for the knee joint. Preferably, posterior stiff cuff members

extend between the rigid support members behind the leg and the thigh to firmly capture the lower thigh and upper leg above and below the knee joint. This leaves the knee joint free, and, unlike other braces which capture the knee, this device maintains proper alignment of the pivot points of the elongated members through positioning of the rigid posterior strut during flexion by the soft tissue of the popliteal area. Preferably, additional anterior, generally triangular, stiff cuff members extend from the superior lateral rigid support member and the inferior medial rigid support member to the opposite terminal portion of the rigid posterior strut.

The invention further includes a posterior strut, and a knee brace incorporating the posterior strut, which is adjustable in many degrees of freedom to accommodate for individual joint characteristics and abnormalities, and changes thereof, and to reduce the number of sizes of the brace which must be stocked.

More particularly, the terminal members of the strut are connected to the arcuate center member by mounting means adjustably fixing the terminal members to the ends of the arcuate member in selected positions. Such adjustments include axial and rotational positioning of the terminal members relative to the longitudinal axis of the arcuate member. They may further include rotational adjustment of the terminal members about lateral and vertical axis transverse to the longitudinal axis of the arcuate member.

The mounting means also includes attachment means fixing the terminal members to the mounting members in selectable positions. Preferably, the attachment means is a ball and socket connection. With this arrangement, the terminal members may be fixed in any angular position desired relative to the arcuate member and the

anterior/posterior size of the strut can be adjusted.

The knee brace incorporating the strut has generally triangular, stiff cuffs secured along one edge to one of the support members hinged to the terminal members and extending either upward along the thigh or downward along the leg. The opposite vertex is pivotably connected to the terminal member on the opposite side. These cuffs are anterior to the thigh and leg and are bowed so that they can accommodate for small adjustments of the terminal members. For larger adjustments, the cuffs are attached to the elongated member by a pivot member and fastening means spaced from the pivot member which accommodates for rotation of the cuff about the pivot member to a selected angular position and fixedly secures the cuff to the elongated support member at the selected angular position. Preferably, the fastening means are slots in the cuffs and fasteners extending through the slots and clamping the cuffs in the selected positions.

BRIEF DESCRIPTION OF THE DRAWINGS

A full understanding of the invention can be gained from the following description of the preferred embodiments when read in conjunction with the accompanying drawings in which:

Figure 1 is a front elevation view of a knee brace in accordance with one embodiment of the invention shown in use.

Figure 2 is an exploded isometric view of the knee brace of Figure 1.

Figure 3 is a front elevation view of a knee brace in accordance with another embodiment of the invention.

Figure 4 is a side elevation view of the knee

brace of Figure 3.

Figure 5 is side elevation view of a knee brace in accordance with the invention with the leg in extension.

Figure 6 is a side elevation view similar to Figure 5 showing the leg in flexion.

Figure 7 is a vertical section through a terminal portion of the rear strut which forms a part of the knee brace of the invention.

Figure 8 is a top plan view of a terminal portion of the rear strut.

Figure 9 is an isometric view in enlarged scale of a modified, adjustable posterior strut which forms a part of the knee brace of the invention.

Figure 10 is a fragmentary view, partially in section, of one end of the posterior strut shown in Figure 9.

Figure 11 is a fragmentary side view of a portion of the knee brace of the invention utilizing the adjustable posterior strut of Figures 9 and 10 illustrating a mechanism for adjustment of the cuffs.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 illustrates a knee brace in accordance with the invention in use in supporting and stabilizing a knee joint 1 of a human right lower extremity 3. The knee joint 1 is formed by the enlarged ends of the femur 5, which is the bone of the thigh 7, and the upper end of the tibia 9 which together with the fibula 11 form the bones of the leg 13. The patella (knee cap) 14 articulates with the distal end of the femur 5.

The joint 1 is held together by an arrangement of

ligaments including the anterior cruciate ligament 15, the posterior cruciate ligament 17, the lateral collateral ligament 19 and the medial collateral ligament 21. Shear forces and torsional forces applied to the knee joint can result in stretching, and even tearing of these ligaments. A common injury occurs when a lateral blow is applied to the outside of the thigh with the foot planted. This causes the knee joint to buckle inward resulting in tearing of the medial collateral ligament 21, and occasionally the anterior cruciate ligament as well.

The knee brace 23 shown in Figures 1 and 2 is a prophylactic brace. It includes a rigid posterior strut 25. The strut 25 has an arcuate section 27 which extends behind the knee joint 1 through the popliteal area 29 (see Figure 5) and terminates in enlarged terminal portions 31 and 33 adjacent, but spaced from the lateral and medial sides, respectively, of the joint 1. If desired, the arcuate section 27 can be covered by a soft resilient sleeve 28.

An inferior lateral rigid elongated support member 35 is pivotally connected to the lateral terminal portion 31 of the rigid posterior strut 25 at a first pivot point by a pivot pin 37 and extends down along the lateral side of the leg 13. A superior medial rigid elongated support member 39 is pivotally connected to the terminal portion 33 of the rigid posterior strut 25 at a second pivot point by pivot pin 41, and extends upward medially along the thigh 7.

The support members 35 and 39 are secured to the leg 13 and thigh 7 respectively by anchoring devices 43 and 45. The anchoring devices 43 and 45 each include a sleeve 47 of a non-slip, cushioning material, such as for instance, neoprene, and a pair of straps 49 which are threaded through

buckles 51 on the support member 35 and 39 and secured by VELCRO fasteners 53. These anchoring devices 43 and 45 firmly secure the support members 35 and 39 to fleshy portions of the leg 13 and thigh 7, respectively, so that forces are transmitted through these support members into the large muscles of the extremity 3.

The prophylactic brace 23 is also provided with a pair of stiff, semirigid anterior cuff members 55 and 57. These cuff members are generally triangular in shape with one edge 59 secured to the associated elongated support member 35 or 39, and with the opposing vertex 61 pivotally connected such as with a snap fastener 63 to a connection point on the terminal portion 31 or 33 of the rigid posterior strut 25 opposite to the terminal portion to which the associated support member 35 or 39 is secured. The pivots formed by the fasteners 63 are laterally aligned with the corresponding pivot points of the elongated members to which the cuffs are attached along the edge 59. The cuff members 55 and 57 are unsnapped and opened for applying the brace 23 to the extremity 3, and then are wrapped around in front of the thigh and leg and snapped in place.

With the prophylactic brace 23 in place, lateral blows to the leg 13 are partially absorbed by the muscles in the leg 13 with the remainder transmitted through the posterior rigid strut 25 to the elongated medial support member 39 which pulls the thigh 7 laterally with the leg and dissipates the transmitted energy into the muscles of the thigh. For a lateral blow to the thigh 7, the force not absorbed by the thigh muscles is transmitted by the elongated support 39, around the knee joint 1 by the rigid posterior strut 25, and through the elongated support member 35 into the fleshy portion of the leg 13. The torsion force generated by rotation of the thigh 7 with the foot planted

is transmitted around the knee joint 1 by the rigid posterior strut 25, and through the elongated member 35 into the leg 13. The stiff cuff members 55 and 57 help to balance the rotational forces and to dissipate additional energy into the leg muscles. Anterior and posterior forces applied to the leg 13 or the thigh 7 are similarly transmitted around the knee joint 1 through the rigid posterior strut 25 with the assistance of the stiff cuff members 55 and 57.

Figures 3 and 4 illustrate a functional brace 65 in accordance with the invention. The lower portion of brace 65 is shown open in Figure 3 for application to the leg. In this brace, parts corresponding to similar parts in the prophylactic brace 23 of Figures 1 and 2 are identified by the same reference characters. This functional brace 65 also includes an inferior medial rigid elongated support member 67 pivotally connected to the terminal portion 33 of the rigid posterior strut 25 at a pivot point coaxial with the snap fastener 63. The functional brace 65 also includes a superior lateral support member 69 which is pivotally connected to the lateral terminal portion 31 of the strut 25 at a pivot point coaxial with the snap fastener 63, and is secured to the thigh by the straps 49.

The functional brace 65 also includes, in addition to the generally triangularly shaped anterior cuff members 55 and 57, posterior, semicylindrical stiff cuff members 71 and 73 which extend between the respective medial and lateral support members extending along the sides of the leg 13 and thigh 7, respectively.

The brace 65 includes additional stiff, semirigid anterior, generally triangular, cuff member 56, secured to elongated member 67 and connected by a snap fastener 63 to

terminal portion 31, and cuff member 58, secured to elongated member 69 and connected by snap fastener 63 to terminal portion 33. These additional cuffs 56 and 58 criss-cross with the cuffs 55 and 57 anterior to the leg and thigh, respectively.

The functional brace 65 with both medial and lateral support members for the thigh and leg and the added cuff members, add additional support and stability to the knee joint.

Operation of knee braces in accordance with the invention is illustrated by Figures 5 and 6. With the leg extended as shown in Figure 5, the rigid posterior strut 25 extends substantially horizontally, rearward into the popliteal area 29 behind the knee joint 1. When the joint is flexed as shown in Figure 6, the fleshy posterior portions of the leg (the calf) and thigh reposition the rigid posterior strut 25. This repositioning rotates the terminal portions 31 and 33 so that the pivot points at which the inferior and superior support members are attached are rotated to accommodate for the femoral rollback which is illustrated in Figure 6. Thus, in the knee braces in accordance with the invention, the brace is automatically positioned by the natural movement of the leg, thus eliminating the need for complex joint mechanisms which are sometimes ineffective because of slippage of the brace during flexion and extension.

Figures 5 and 6 also illustrates that one or two anterior struts 76 can be secured to the terminal portions 31 and 33 for protecting the knee joint 1 from forces acting frontally or posterior forces forcing the tibia forward. The forces generated by such action are transmitted through the strut 25 to the elongated support members for

dissipation in the major muscles in the leg and thigh. The anterior struts 76 form with the posterior strut 25 a rigid support completely surrounding the knee joint and through which forces applied to the limb are transmitted around the knee joint.

The terminal portions 31 and 33 of the rigid posterior strut 25 also serve as reference or attachment points for other devices, such as for instance, a patella stabilizer 74 as shown in Figures 5 and 6.

The hinges formed by the terminal portions 31 and 33 of the rigid posterior strut 25 and the elongated support members can be configured to limit movement of the joint for functional or rehabilitative applications. For instance, as shown in Figure 7, which is a vertical section through the terminal portion 33 of the strut 25, a cam 75 has a vertical edge 77 which is engaged by the pivoting elongated support means such as 39 and 67 to limit extension of the joint, and biased shoulders 79 which restrict rotation of the elongated members to limit flexion of the joint. A pin 81 may be inserted in one of a number of holes 83 to limit extension of the knee joint to less than full extension. Similarly, a pin 85 may be inserted in a selected hole 87 to restrict flexion.

Figure 9 illustrates in detail a modified form 125 of the rigid posterior strut 25 which is adjustable. The strut 125 comprises an arcuate member 127 and terminal member 131 and 133 which are secured to the arcuate member 127 by mounting members 135 and 137 respectively. The arcuate member 127 has a longitudinal axis 165 and is composed of two halves 167 and 169, each of which is substantially a 90° sector of a circle. Confronting ends of the halves 167 and 169 have longitudinal bores 171. An

elongated piece in the form of a pin 173 telescopes into the bores 171. Each of the halves 167 and 169 has a slit 175 extending the length of the bore 171. Confronting radial flanges 177 along either side of the slits 175 are drawn together by screws 179 to form clamps which secure the ends of the pin 173 in the bores 171 in a fixed position.

The free ends 181 and 183 of the halves 167 and 169, respectively, have longitudinal bores 185. Slots 187 through the walls of the arcuate members extend a substantial length along the bores 185. Confronting radial flanges 189 on either side of the slots 187 are drawn together by additional screws 191 to form clamps for securing the mounting members 135 and 137 to the arcuate member 127 as will be seen.

The mounting members 135 and 137 each have an elongated member in the form of a stem 193 which telescopes into the bore 185 in one of the halves 167 and 169 of the arcuate member 127 and is secured in a fixed position by the clamps formed by the flanges 189 and screws 191.

The terminal members 131 and 133 are secured to the mounting members 135 and 137, respectively, by adjustable attachments on the mounting members, preferably in the form of ball and socket connectors 195. As shown in Figure 5, these connectors 195 include balls 197 on the ends of the mounting members 135 and 137. Bosses 199 on the rear edges of the terminal members 131 and 133 have rearwardly facing bores with spherical bottoms 201 which define the sockets for the balls 197. Lock nuts 203 which thread onto the outer surface of the bosses 199 clamp an annular ring 205 with a spherical inner surface against the ball 197 to lock the terminal members 131 and 133 in fixed positions relative to the mounting members 135 and 137.

As can be appreciated from Figure 9, the adjustable rigid posterior strut 125 of the invention offers great flexibility in the adjustment of the brace. The adjustable connection between the two halves 167 and 169 of the arcuate member 127 of the posterior strut 125 allows adjustment of the lateral/medial distance between the terminal members 131 and 133 by loosening the screws 179, sliding the stem 173 in the bores 171, and then fixing the two halves in this position by tightening the screws 179. Adjustment of the position of the terminal members 131 and 133 relative to each other in the sagittal plane can be made by again loosening the screws 179 and rotating the halves 167 and 169 about the stem 173 to a desired position and then retightening the screws 179. Preferably, the stem 173, and the bores 171 are fluted as at 207 to aid in fixing the angular position of the two halves 167 and 169.

The strut 125 may be adjusted in the anterior/posterior direction through loosening of the screw 191 and sliding the stems 193 of the mounting members 135 and 137 inward or outward in the bores 185 in the ends 181 and 183 of the arcuate halves 167 and 169, and then retightening the screws 191. By loosening the screws 191 and rotating the mounting members 135 and 137 about the longitudinal axis 165 of the arcuate member 127 and then retightening the screws 191, the terminal members 131 and 133 can be rotated in the coronal plane to a desired fixed position relative to the arcuate member 127. Again, the stems 193 and bores 185 can be fluted as at 209 to lock the mounting members 135 and 137 in fixed positions relative to the arcuate members 127 with less torque required on the screws 191.

The ball and socket connectors 195 permit adjustment of the terminal members 131 and 133 in all three

planes about the superior/inferior, medial/lateral and anterior/posterior axes relative to the mounting members 135 and 137.

Figure 11 illustrates a mechanism for adjustment of the anterior cuffs 155 which may be necessitated by adjustments, especially large adjustments, to the posterior strut 125. A pin 211 forms a fixed pivot for attaching the cuff member 57 to the elongated support member 39. Fasteners in the form of screws 113 extend through arcuate slot 215, which are generally transverse to the edge 59 of the cuff and spaced above and below the pivot pin 211. The screws 213, which are threaded into the elongated support member 39, are loosened to adjust the angular position of the cuff member 57 to align the vertex 61 with the fastener 63 on terminal member. The need for and the amount of this rotation is determined by the adjustment, if any, made to the posterior strut 125. The screws 213 are then tightened to clamp the cuff member 57 to the elongated support member 39 in the desired fixed angular position. A similar adjustment mechanism is provided for the cuff 55 secured to the other elongated support member 35.

As the adjustable rigid posterior strut 125 serves as the central element to which the other elements of the brace 123 are connected, either directly or indirectly, the various adjustments made to the posterior strut 125 set the position of the other elements. The versatility of the adjustable knee brace in accordance with the invention allows an off the shelf brace to be used for patients with extremities of various sizes and shapes. Only a very few, perhaps two or three, sizes of brace need be stocked, as those stocked parts can be assembled and adjusted to cover a full range of sizes. Furthermore, the versatility of the adjustable brace allows it to be customized for the invariable deviations from the ideal knee joint and for a

large range of deformities caused by disease or injury. Furthermore, the brace can be periodically adjusted during use to accommodate for changes such as the growth of a child, or a reduction in swelling.

The following table indicates in general terms exemplary problems or deformities, the conditions which typically give rise to this problem or deformity and the major adjustment to the posterior strut which may be used to compensate for this condition. It will be obvious that in many instances, the major adjustment will give rise to the need for additional adjustments at other connections to maintain the correct kinematics of the knee joint. For instance, if the two halves 167 and 169 of the arcuate member 127 are rotated about the pin 173, it may be necessary to rotate the mounting members 135 and 137 about the stem portions 193 and to adjust the ball and socket connections to maintain the terminal members 131 and 135 generally perpendicular to the axis of rotation of the knee joint.

TABLE 1

COMMON KNEE PROBLEMS AND RELATED CORRECTIONS USING POSTERIOR STRUT BRACE

PROBLEM OR DEFORMITY	COMMON ASSOCIATED CONDITIONS	CORRECTION OF PROBLEM
Varus Deformity (bowed-kneed)	Osteoarthritis, Developmental	Tilt Posterior Strut in Coronal Plane (medial high) - rotate 167-169 about 173
Valgus Deformity (knock-kneed)	Rheumatoid Arthritis, Osteoarthritis, Post-Traumatic	Tilt Posterior Strut in Coronal Plane (lateral high) - rotate 167 and 169 about 173

PROBLEM OR DEFORMITY	COMMON ASSOCIATED CONDITIONS	CORRECTION OF PROBLEM
Internal Rotation Deformity (pigeon-toed)	Developmental or Posti-traumatic Posteriolateral Ligamentous Laxity	Adjust Strut in Horizontal Plane Slide 193 in 185 (Elongated Laterally)
External Rotation Deformity (ballet dancer)	Developmental or Post-traumatic Posteromedial Ligamentous Laxity	Adjust Strut in Horizontal Plane (extend on one side) - Slide 193 in 185 (Elongated Medially)
Flexion Contracture (can't straighten leg)	Osteoarthritis Post-operative, Rheumatoid Arthritis, Post-traumatic	Adjust Strut about Axis of Rotation. Rotate 131 or 133 relative to 127
Extension Deformity	Developmental or Post-traumatic Ligamentous Laxity	Adjust Strut about Axis of Rotation. Rotate 131 or 133 relative to 127
Growing Child	Normal Development of joints	Expand Strut. slide 167 and 169 on 173. Slide 193 out of 185
Right/Left Differences	Various	Individually adjust L/R as required.
Swollen Knee	Post-traumatic or Post-operative Phlebitis	Expand Strut Slide 167 and 169 on 173
Atrophied Knee	Post-injury Atrophy	Contract Strut Slide 167 and 169 on 173

It can be seen from the above that the ajustable posterior strut 125 provides great versatility to offset the axis of rotation of the brace, as well as individually adjust the lateral to medial distance and offset the vertical axis of action of the affected hinge point to compensate for individual knee characteristics, or to provide the surgeon/physiotherapist a means for adjusting for abnormal knees; for either improved brace fit; optimizing the brace function/action for individual patients; or compensating for, or controlling specific motions or actions.

While specific embodiments of the invention have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting as to the scope of the invention which is to be given the full breadth of the appended claims and any and all equivalents thereof.

What is claimed is:

1. A brace (23) for a knee joint (1) joining thigh (7) and leg (13) limb members, said brace comprising:

first and second rigid support members (39, 35) only;

first anchoring means (45) securing said first rigid support member (39) to the thigh (7) along a fleshy portion of a first side of the thigh with a lower end of said first rigid support member adjacent to but spaced from a first side of the knee joint;

second anchoring means (43) securing said second rigid support member (35) to the leg (13) along a fleshy portion of a second side of the leg with an upper end of said second rigid support member adjacent to but spaced from a second side of the knee joint; and

a rigid posterior strut (25) having a first terminal portion (33) pivotally connected at a first pivot point (41) to said lower end of said first rigid support member (39) and inwardly spaced from the first side of the knee joint (1), a second terminal portion (31) pivotally connected at a second pivot point (37) to said upper end of said second rigid support member (35) and outwardly spaced from the second side of the knee joint (1), and a rigid arcuate section (27) extending between said terminal portions through a popliteal space (29) behind the knee joint, said rigid posterior strut (25) being clamped between the thigh and leg to position said first and second pivot points upon flexion of the knee joint.

2. The brace of claim 1 including:

a first stiff anterior cuff member (57) secured to said first rigid support member (39) and

extending around in front of the thigh (7) and pivotally connected to said second terminal portion (31) of said rigid posterior strut (25); and

a second stiff anterior cuff member (55) secured to said second rigid support member (35) and extending around in front of the leg (13) and pivotally connected to said first terminal portion (33) of said rigid posterior strut (25).

3. The knee brace of claim 2 wherein said first and second stiff anterior cuff members (55, 55) are each generally triangular members having a side edge (59) and a vertex (61) opposite the side edge, the side edge (59) of said first stiff cuff member (57) being secured along said first rigid support member (39) and the vertex of the first stiff cuff member pivotally connected to said second terminal portion (31) of said rigid posterior strut (25) at a connection point (63) laterally aligned with the first pivot point (41) on said first terminal portion (33) of said rigid posterior strut (25) and the side edge (59) of said second stiff cuff member (55) being secured along said second rigid support member (31) and the vertex (61) of the second stiff cuff member pivotally connected to said first terminal portion (33) of said rigid posterior strut at a connection point (63) laterally aligned with said second pivot point (37) on the second terminal portion (31) of said rigid posterior strut.

4. The knee brace of claim 3 including releasable pivoting connection means (63) pivotally connecting the vertices (61) of said first and second generally triangular anterior cuff members (57, 55) to said connection points.

5. The knee brace of claim 2 including limiting means (79, 85) limiting pivoting of said rigid support

members (39, 33) relative to said first and second end portions of said rigid strut.

6. The knee brace of any one of claims 1-5 wherein said thigh (7), leg (13) and knee joint (1) have a medial side and a lateral side and wherein the first side is the medial side and the second side is the lateral side.

7. A brace (65) for a knee joint (1) joining thigh (7) and leg (13) limb members, said brace comprising:

first, second, third and fourth rigid support members (39, 35, 69, 67);

first anchoring means (45) securing said first rigid support member (39) to the thigh along a fleshy portion of a medial side of the thigh with a lower end of said first rigid support member adjacent to but spaced from a medial side of the knee joint, and securing said third rigid support member (69) to said thigh along a fleshy portion of a lateral side of the thigh with a lower end of said third rigid support member adjacent to but spaced from a lateral side of the knee joint;

second anchoring means (43) securing said second rigid support member (35) to the leg along a fleshy portion of a lateral side of the leg with an upper end of said second rigid support member adjacent to but spaced from a lateral side of the knee joint, and securing said fourth rigid support member (67) to the leg along a fleshy portion of a medial side of the leg with an upper end of said fourth rigid support member adjacent to but spaced from a lateral side of the knee joint;

a rigid posterior strut (25) having a first terminal portion (33) pivotally connected at a first pivot point to said lower end of said first rigid support member (39) and pivotally connected at a fourth pivot point to said

upper end of said fourth rigid support member (67) and inwardly spaced from the medial side of said knee joint, a second terminal portion (31) pivotally connected at a second pivot point to said upper end of said second rigid support member (35) and pivotally connected at a third pivot point to the lower end of said third rigid support member (69) and outwardly spaced from the lateral side of said knee joint, and a rigid arcuate section (27) extending between said terminal portions (33, 31) through a popliteal space (29) behind said knee joint, said rigid posterior strut being clamped between said thigh and leg to reposition said pivot points upon flexion of the knee joint to accommodate for femoral rollback; and

first, second, third and fourth stiff anterior cuff members (57, 55, 58, 56) each generally triangular and having a side edge (59) and a vertex opposite the side edge, the side edge of said first stiff cuff member (57) being secured along said first rigid support member (39) and the vertex of the first stiff cuff member (57) pivotally connected to said second terminal portion (31) of said rigid posterior strut (25) at a connection point laterally aligned with the first pivot point on said first terminal portion (33) of said rigid posterior strut, the side edge of said second stiff cuff member (55) being secured along said second rigid support member (35) and the vertex of the second stiff cuff member pivotally connected to said first terminal portion (33) of said rigid posterior strut at a connection point laterally aligned with said second pivot point on the second terminal portion (31) of said rigid posterior strut, the side edge of said third stiff cuff member (58) being secured to said third rigid support member (69) and the vertex of the third stiff cuff member pivotally connected to said first terminal portion (33) of said rigid

posterior strut at a connection point laterally aligned with the third pivot point on said second terminal portion (31) of said rigid posterior strut, said third anterior cuff member (58) extending around in front of the thigh and criss-crossing with said first stiff anterior cuff member (57), and the side edge of said fourth stiff cuff member (56) being secured to said fourth rigid support member (67) and the vertex pivotally connected to said second terminal portion (31) of said rigid posterior strut at a connection point laterally aligned with said fourth pivot point on said first terminal portion (33) of said rigid posterior strut, said fourth anterior cuff member (56) extending around in front of the leg and criss-crossing with said second stiff anterior cuff member (55).

8. The knee brace of claim 7 including a first stiff, posterior cuff member (73) extending between said first and third rigid support members (39, 69) posterior to the thigh and a second stiff posterior cuff member (71) extending between said second and fourth rigid support members (35, 67) posterior to the calf.

9. The brace of claim 8 including releasable pivoting connection means (63) pivotally connecting the vertices of said generally triangular anterior cuff members (57, 55, 58, 56) at said connection points.

10. The knee brace of any one of claims 1-9 wherein said rigid posterior strut (125) includes means (137, 135) adjustably fixing said terminal portions (133, 131) of said rigid posterior strut in selected positions relative to said rigid arcuate section (127).

11. An adjustable rigid posterior strut (125) for a knee brace having elongated leg attachment members (39, 35), said strut comprising:

a rigid arcuate member (127) having first and second ends (183, 181) and a longitudinal axis (165); first and second terminal members (133, 131) having pivot connections for said elongated attachment members; and first and second adjustable mounting members (137, 135) adjustably fixing said first and second terminal members to said first and second ends respectively of said arcuate member in selected positions relative to said arcuate member.

12. The strut of claim 11 wherein said first and second mounting means (137, 135) include mounting members having elongated members (193) extendable axially with respect to said first and second ends (183, 181) of said arcuate member (127) and rotatable about said longitudinal axis (165) of said arcuate member, and first and second securing means (189, 191) fixedly securing said elongated members in selectable axial and rotational positions relative to said first and second ends respectively of said arcuate member.

13. The strut of claim 12 wherein said first and second mounting means (137, 135) further include first and second adjustable attachment means (195) fixing said first and second terminal members (133, 131) in selectable positions to said first and second mounting members.

14. The strut of claim 13 wherein said first and second adjustable attachment means (195) comprise ball and socket connections between said first and second terminal members (133, 131) respectively, and one of said mounting members (137, 135), and tightening means (203) fixing said ball and socket connections with said first and second terminal members in selected positions relative to the mounting members.

15. The strut of any one of claims 11-14 wherein said arcuate member (127) comprises first and second halves

(169, 167) rotatable about said longitudinal axis (165) to selectable angular positions with respect to one another and are extendable axially along said longitudinal axis to selected axial positions relative to one another, and connecting means (173, 177, 179) fixedly connecting said first and second halves together at a selected angular and a selected axial position.

16. The knee brace of claim 3 wherein said rigid posterior strut (125) includes means (137, 135) adjustably fixing said terminal portions (133, 131) of said rigid posterior strut (125) in selected positions relative to said rigid arcuate section (127), and wherein said cuff members (57, 55) include attaching means (211, 213) firmly securing the side edges (59) in selected ones of at least two positions relative to said rigid support members (39, 35).

17. The knee brace of claim 16 wherein said attaching means comprise pivot members (211) pivotally securing pivot points along the side edges (59) of the cuff members (57, 55) to the rigid support members (39, 35), and fastening means (213) spaced from said pivot members accommodating rotation of said cuff members about the pivot points to selected angular positions, and fixedly securing said support edges to said rigid support members at said selected angular positions.

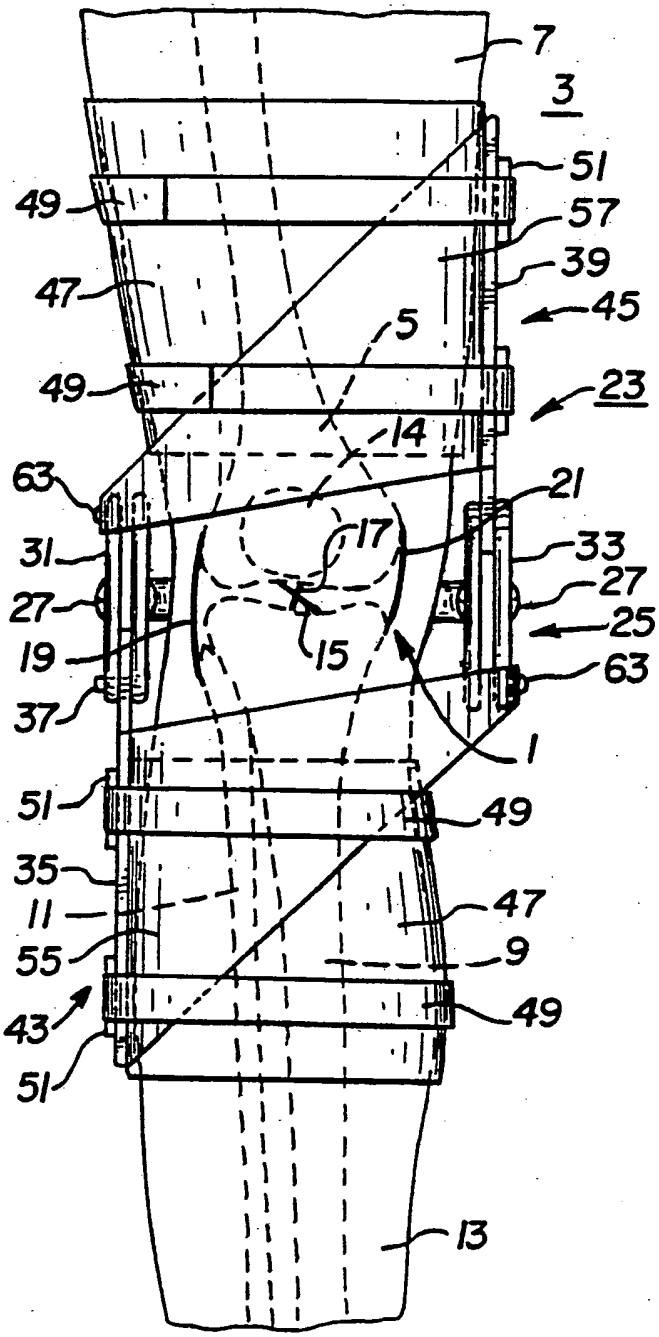
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FIG. 1

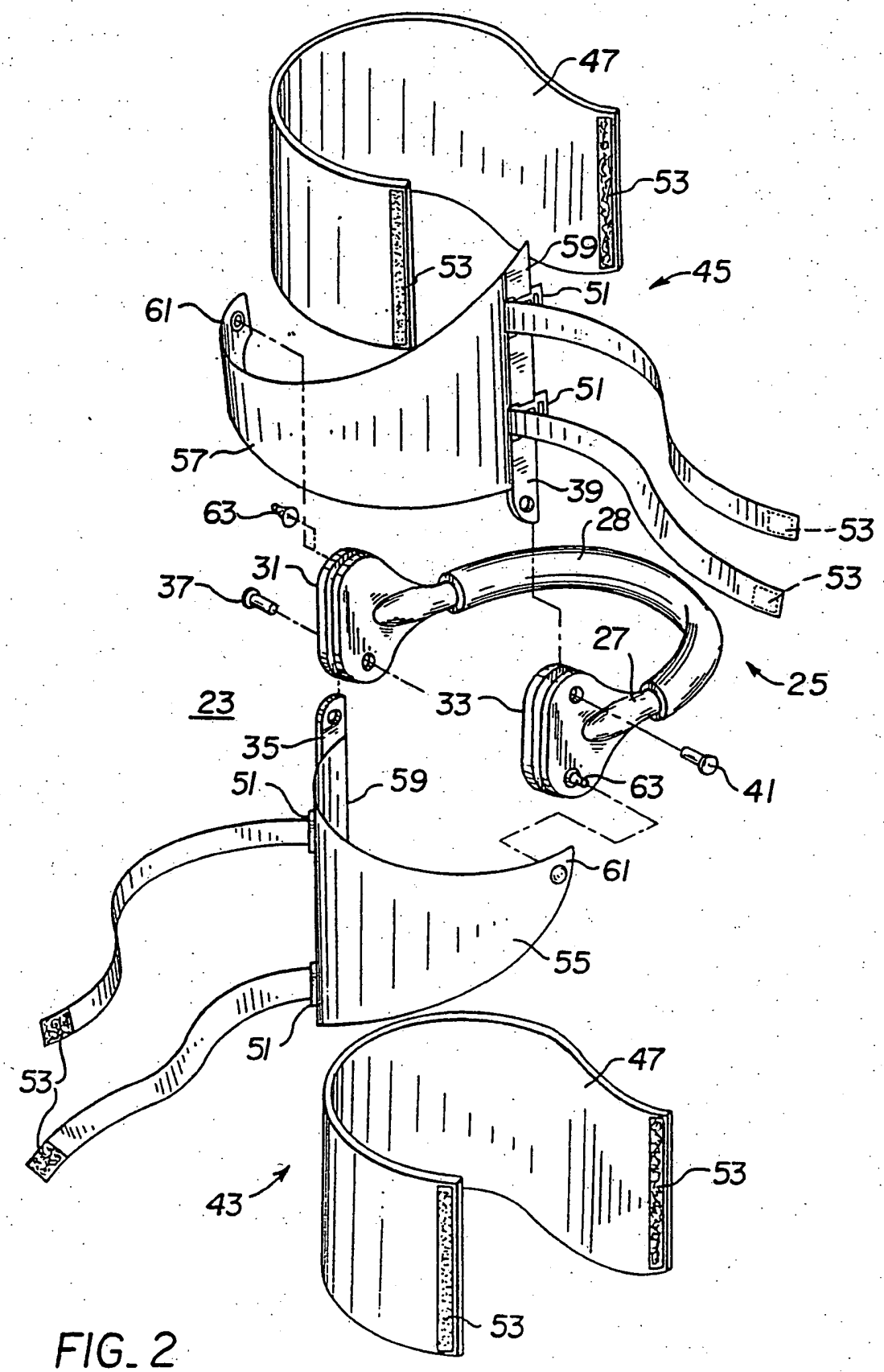
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FIG. 2

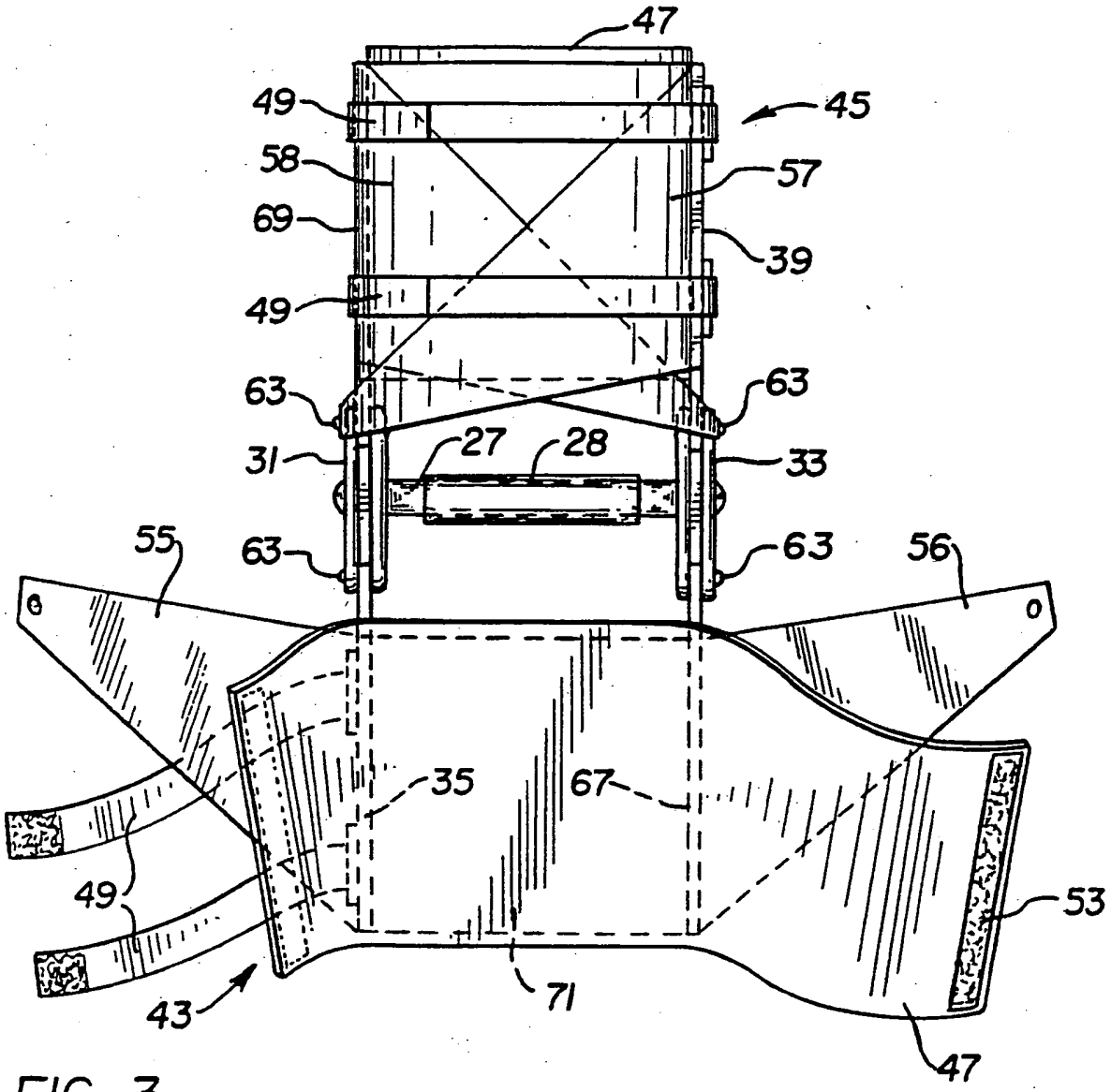
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FIG_3

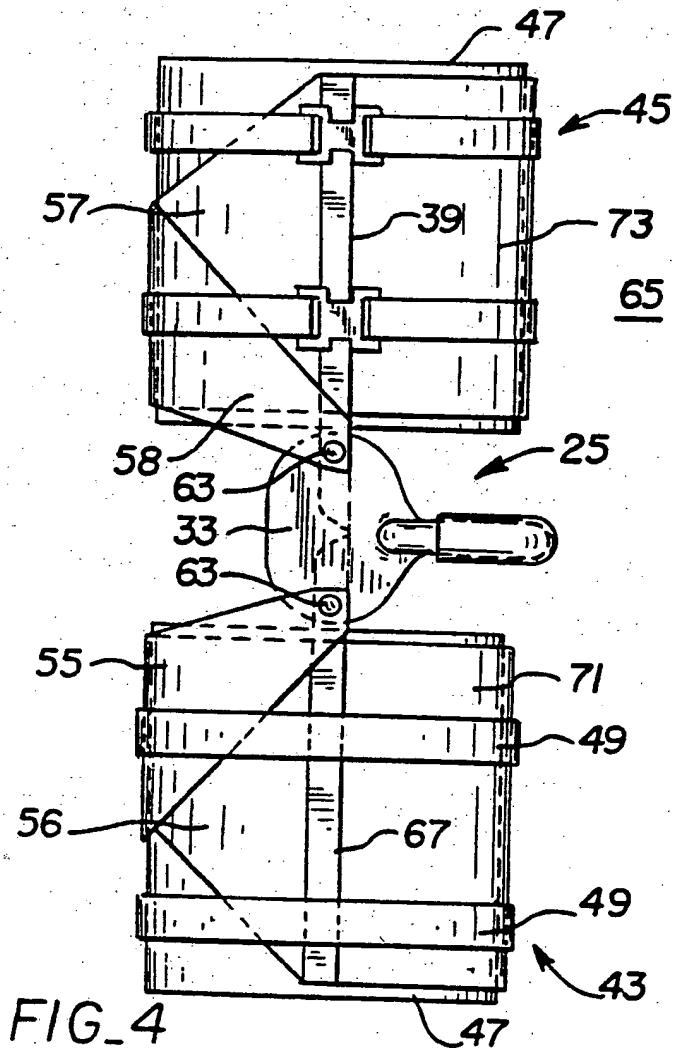

FIG_4

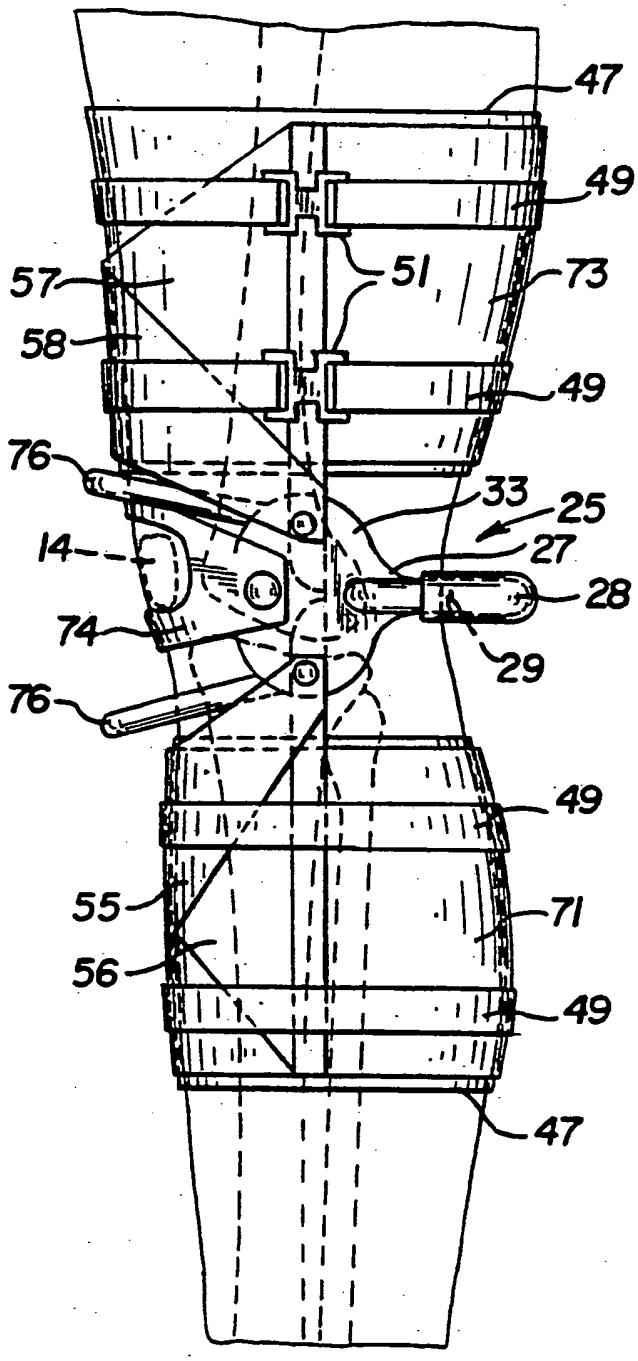

FIG_5

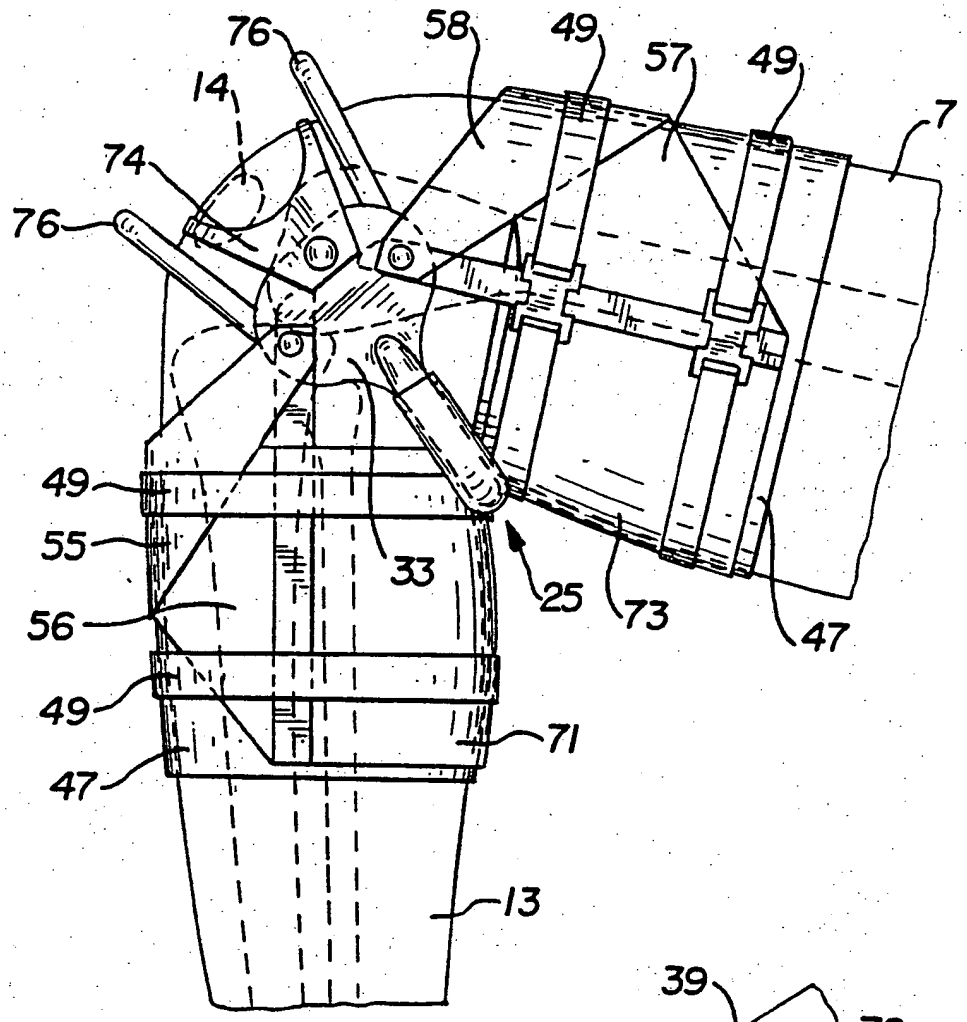

FIG_6

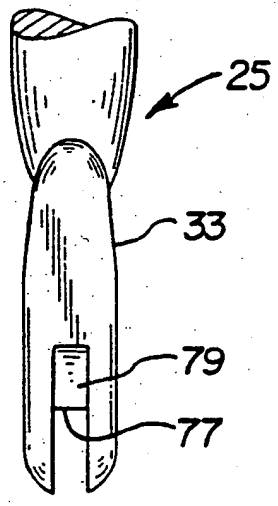

FIG_8

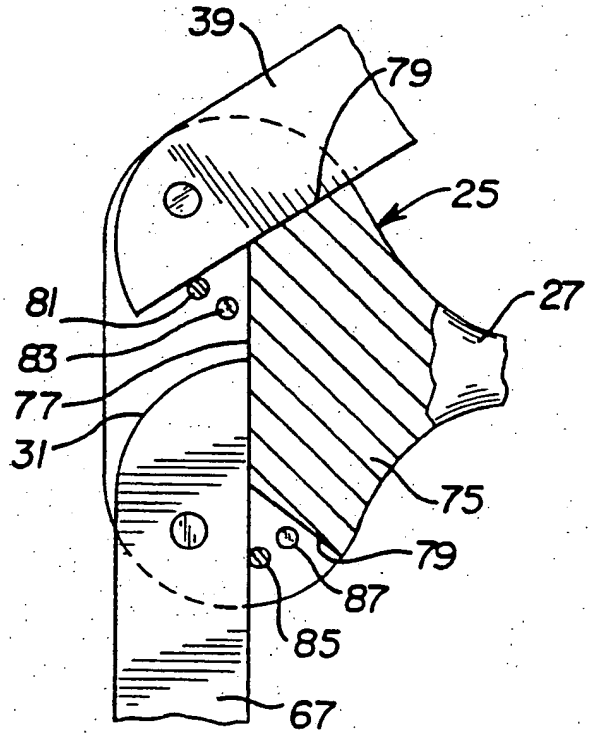

FIG_7

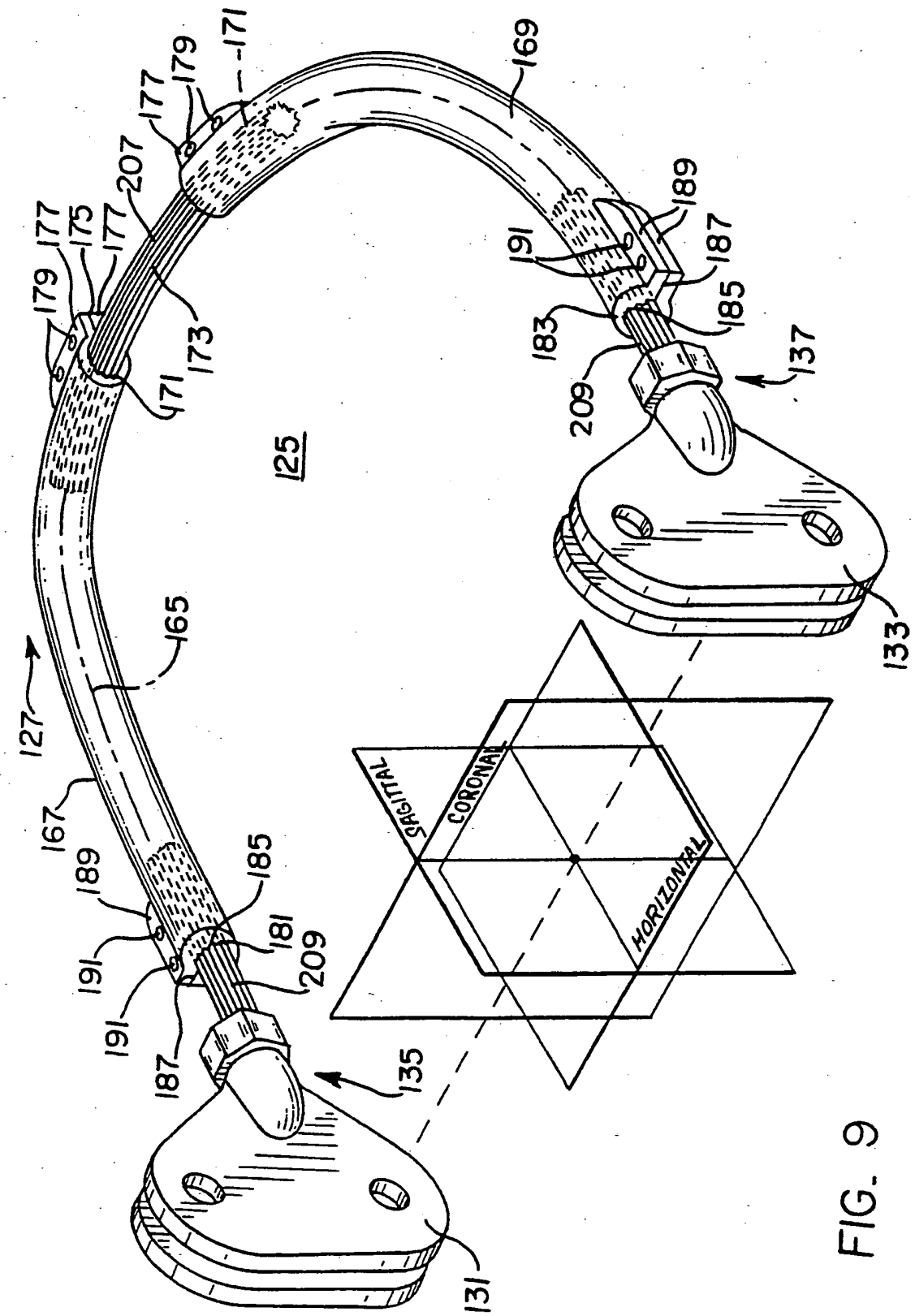
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FIG. 9

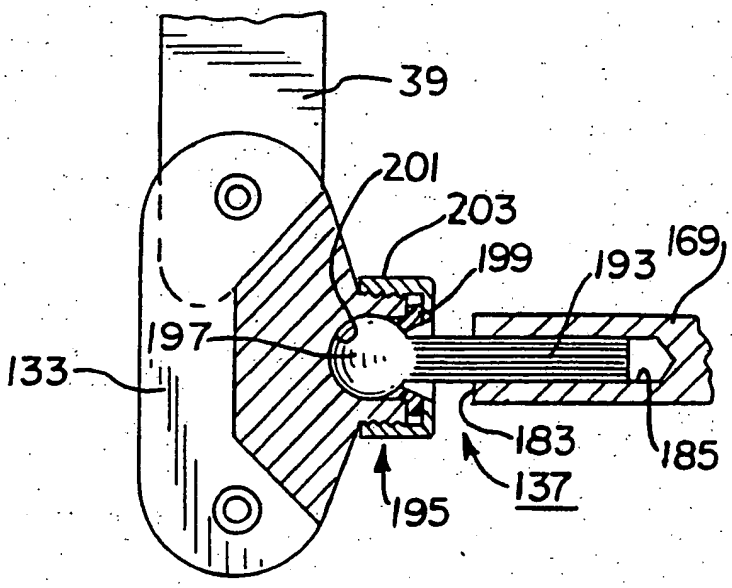
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FIG. 10

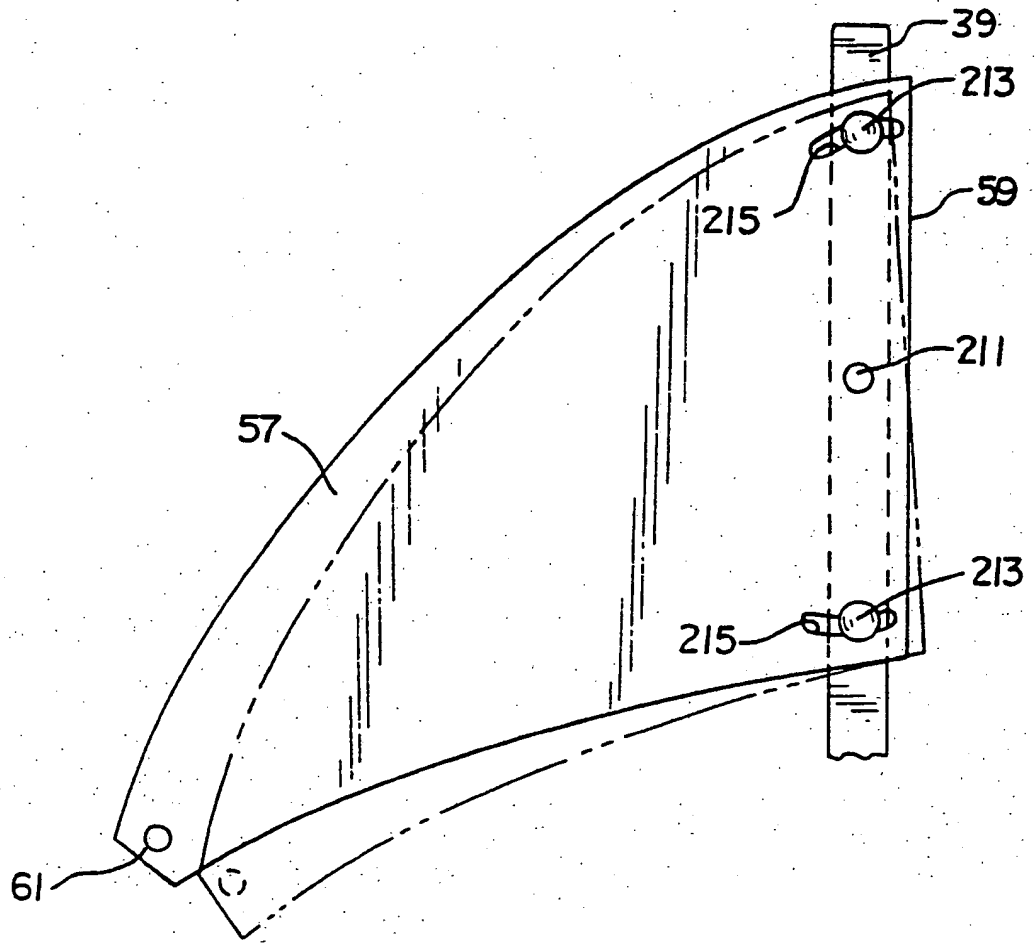
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FIG. 11

International application No.
PCT/US92/03903

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A61F 5/00

US CL : 602/16, 26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 602/16, 26 602/5,23

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB,A, 2,215,213 A (YOUNG ET AL) 20 September 1989. See Entire document.	1-17
A	FR,A, 2,552,660 (DELBOS) 05 April 1985, note items 15, 16.	1-17
A	US,A, 4,088,130 (APPLEGATE) 09 May 1978. See entire document.	1-17
X	US,A, 3026,869 (PEACH) 27 March 1962 Note figures 2 and 3, items 13,14.	11

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 30 JULY 1992	Date of mailing of the international search report 23 SEP 1992
Name and mailing address of the ISA/ Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer LINDA DVORAK Telephone No. (703) 308-0858

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